GROUNDS FOR AND METHODS OF TOTAL REMOVAL

OF VIII NERVE NEURINOMAS

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OF VIII NERVE NEURINOMAS

[Following is the translation of an article
by B. G. Yegorov entitled Obosnovaniye i Me-
todika Total'nogo Udaleniya Nevrinom VIII
Nerva, (English version above), in Voprosy
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3-13.]

In 1949, B. G. Yegorov published a monograph,

"Neurinoma of the VIII Nerve", in which the results were

summarized of a comparatively small number of observations

made at the Institute of Neurosurgery of the Academy of Medical

Sciences USSR imeni N. N. Burdenko (136 patients operated

from 1932 through 1940). In the monograph a conception was

presented of the histogenetic and morphological unity of

neurinomas, and it was shown that their polymorphism depends

on exogenous and endogenous causes and is brought about by

regressive and involutionary changes.

Clinical analysis, the study of the pathogenesis,

morphology of the tumor and the late results made it possible

even at that time to assert that the neurinoma is a benign tumor,

grows slowly, develops chiefly from the vestibular portion of

the VIII nerve, and almost always from the segment of it which

is located within the infundibulum of the internal auditory

meatus. A neurinoma nodule which is completely removed does

not recur, but parts of a tumor nodule left behind during the

operation very frequently continue to grow, but never undergo a

loss of differentiation or malignant degeneration.

We consider these principles to be correct, and we cannot

make any changes or corrections at the present time, when the

number of our observations at the Institute has reached almost

1000.

The data of the surgical anatomy and operative approach

for the VIII nerve neurinoma have not lost their value at the

present time either.

During the period when the monograph on the VIII nerve

neurinoma was being published we shared Cushing's viewpoint

concerning the methods of approach and removal of the tumor.

At the Institute, for a long time we adhered to the method

proposed by this author (crossbow-shaped approach), and the

neurinomas were removed by means of enucleation by the Cushing method.

Despite the fact that the crossbow-shaped approach with enucleation by the Cushing method was shown so convincingly by the author to be one of the best, gentlest and one that reduced the mortality rate, considerable operative experience in the removal of neurinomas by this method indicates definitely that it still needs revision.

In 1952, at the Institute more than 600 observations were accumulated on patients operated for VIII nerve tumors. An analysis of these observations led one of us (B. G. Yegorov) to the conviction that the crossbow-shaped Cushing approach can be successfully substituted by a gentler, less traumatic paramedian approach, which shortens the duration of the operation and is better tolerated by the patients. A communication about the surgical anatomy and technique of the operation was published by B. G. Yegorov in the journal "Voprosy neyrokhirurgii /Problems of Neurosurgery/" No 3 for 1952.

The majority of neurosurgeons had a reserved attitude toward W. Dandy's suggestion (1922) that the VIII nerve tumor be operated radically, despite the fact that in 1941 he reported

that after total removal of the tumor the postoperative mortality was equal to 2.4 percent. Such a very great neurosurgeon as Cushing in the book "Intracranial Tumors" describes his vacillations in the choice between enucleation and total removal of the tumor. At that time, he had performed six operations of total removal of a tumor nodule, and he again shifted over to enucleation. N. N. Burdenko in 1937 wrote: "if we compare the results of the operative treatment of VIII nerve tumors by the Cushing method and by the Dandy method we have to draw a very reserved conclusion as to the advantages of the radical operation. While

radical removal of the tumor is not ideal, we must nevertheless consider that at the present time, when the method has not been completely worked out and when the early diagnosis of the VIII nerve tumor is still a rare phenomenon, the operation of Dandy must be called the method of choice".

A study of the statistical data of the Institute of Neurosurgery as well as the data of Olivecrona, Horrax and others shows the following: despite the fact that the immediate postoperative mortality rate after operations of removal of VIII nerve neurinomas by the method of enucleation has been brought to

a negligible percentage, the late mortality in the patients operated (particularly according to Horrax's statistics) reaches 50-60 percent.

Our immediate and late results of operative removal of VIII nerve neurinomas by means of Cushing enucleation show that during the first month after operation 5.3 percent died, and in periods up to five years after the operation 20.7 percent of those operated died. The percentage of recurrences after the operative removal of the VIII nerve tumor by means of enucleation continues to remain high; as far as the mortality rate is concerned after total removal of the VIII nerve neurinomas, according to the data of Olivecrona (1950), it is equal to 23.5 percent.

In comparing the mortality rates after enucleation and total extirpation of the tumor, the conclusion should be drawn that they are different.

It should be emphasized, however, that total removal is a guarantee against further recurrences; enucleation never is. These are the reasons which compel us to revise the method of enucleation which we have adopted and to share our small experience on details of the method of total removal of VIII nerve neurinomas.

Observations show that recently the number of complications in the postoperative period has been reduced which had previously caused the death of the patient. For this we are obliged to the injection of ganglion-blocking agents, potentiated anesthesia, an improvement in the operative technique and, finally, to the appearance of a number of auxiliary diagnostic investigations which make it possible to make an early diagnosis.

It must be supposed that the introduction of the methods of early diagnosis of the VIII nerve neurinoma can reduce the postoperative mortality rate and the postoperative complications to solitary cases.

Before presenting the method of early diagnosis and total removal of the tumor nodule, we shall permit ourselves to mention some data of surgical anatomy in the presence of the VIII nerve tumor and discuss problems of the blood supply of the tumor nodule.

Our observations permit us to determine the fact that the matrix of the tumor, with very rare exceptions, is located at the internal auditory meatus.

The tumor not uncommonly develops from the vestibular portion of the VIII nerve. This is determined by the detection

of changes in the vestibular excitability with intact hearing;

this is also confirmed by the anatomic investigation of

Henschen, Cushing and others (Fig. 1).

Fig. 1. Section of Temporal Bone. Initial Growth of Neurinoma from the Vestibular Portion of the VIII Nerve into the Infundibulum of the Internal Auditory Canal.

a--tumor; b--facial nerve; c--geniculate ganglion (after Lange); d--vestibular nerve.

From the internal auditory meatus the tumor nodule, as

though on rails, travels along the course of the VIII nerve to

the midline (Fig. 2) in the direction of the cerebellopontine angle.

The tumor does not involve the VIII nerve throughout. In the vicinity of the cerebellopontine angle in the glial portion of the auditory nerve it remains unaffected by the tumor, and here it has a kind of "pedicle". The tumor nodule of the VIII nerve, coming out of the internal auditory meatus, may take different directions -- forward along the length of the lateral pontine cisterns or backward to the foramen lacerum posterius.
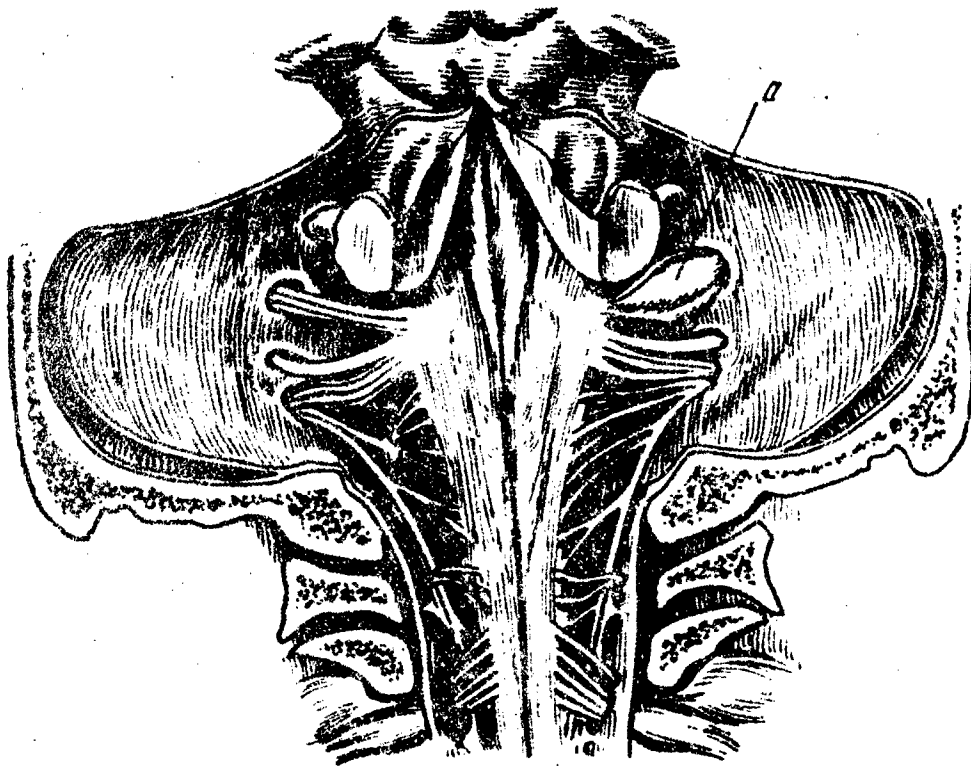

Fig. 2. VIII Nerve Neurinoma in Early Stage of Development.
a--tumor nodule.

These growth variants not uncommonly can be detected

even before the operation on the basis of a study of the successive

occurrence of the clinical symptoms.

In the past two years the attention of the Institute has been

concentrated on the study of neoplasms of the brain stem and

tumors located near the brain stem. Among the latter, mention

should be made of tumors of the lateral pontine cistern. According

to the data of the Institute of Neurosurgery of the Academy of

Medical Sciences USSR, VIII nerve neurinomas constitute 94.6

percent of the tumors located at the lateral pontine cistern.

These figures are different from the data of Tönnis (1956) --

86 percent neurinomas of all the lateral cistern tumors, and

those of Olivecrona (1952), 89 percent.

At the Institute of Neurosurgery of the Academy of Medical

Sciences USSR 995 patients with VIII nerve neurinomas were

operated from 1932 through 1960.

A development of the statistical material of the Institute

showed that women are affected by the VIII nerve neurinoma

twice as often as men. The age most affected is from 25 to 50.

As a rule, the patients arrive late for operative treatment, in

the stages of development of large nodules filling the major

portion of the lateral pontine cistern. The tumor nodules

grossly deform the brain stem and are intimately associated with the vascular system of the brain stem and cerebellum. Only in the case of solitary patients has the operative procedure been performed in the early stages of development of the VIII nerve neurinoma, at a time when the tumor nodule was ~~large~~ the size of a cherry or somewhat larger.

There are undoubtedly a number of difficulties in the problem of lines of early diagnosis of this disease and the elaboration of early indications for operative treatment. It seems to us, they consist of the following: We can never completely evaluate the degree of anatomic and functional disturbances in the brain systems, the conductor systems, cells and nerves, beginning with the block of them and ending with complete destruction. These disturbances are brought about, as we customarily believe, by a displacement of them or by a compression by the growing tumor nodule. It is known what a richness of compensations the brain possesses, particularly if the compression process developed slowly. It has been known for a long time, even since the time of Hippocrates, that an interrelationship exists between the force and resistance. These phenomena also occur under conditions of the development of a tumor nodule in the lateral pontine cistern. The brain resists

the pressure, and disturbances in the circulatory mechanisms are smoothed over.

This has been neatly shown by observations made in the laboratory of Professor S. M. Blinkov (see the author's work in this issue). His investigations on continuous series of microscopic sections of a deformed brain stem of a growing VIII nerve neurinoma have shown that even with very gross displacements of the brain stem with compression and herniation into the opening of the tentorium cerebelli and in the presence of a cerebellar compression cone degeneration of cellular structures and conducting pathways is minimal. The greatest disturbances in function occur as the result of disturbances in the circulation in the brain stem, particularly if they occur acutely in connection with operative trauma. The functional significance of anatomic structures, the topography and the principal variants of abnormalities, particularly in the presence of a pathological process should be taken into consideration and should be known well in order to avoid the development of serious complications. This knowledge is necessary for understanding the sequence of changes which occur in the area of the tumor nodule and for a correct and well founded

diagnosis and operative intervention.

An anatomically-physiologically grounded method of operative treatment eliminates a whole series of disturbances caused by the operation itself. Planned anatomically, the operation creates conditions under which the chances for a better recovery of function and working capacity will be much greater; the smaller the tumor the easier the operative procedure and the greater the chances for a good postoperative course.

Is an early diagnosis possible under modern conditions of clinical investigation in the neurosurgical clinic? Yes, it is possible and we must strive for-it toward it. No difficulties or dangers exist in the technique of neurosurgical operations using approachs to the tumors of the lateral pontine cisterns, and for that reason in cases where the diagnosis is not clear the problem of craniotomy should be put. This operation not only does not do any harm but it introduces clarity and frequently makes it possible to detect the early forms of the disease.

Numerous observations of neurosurgeons have shown that almost in 75 percent of the patients with neurinomas of the auditory nerve the first symptoms of the disease are a lessening of hearing, ringing in the ears, dizziness or a disturbance of

equilibrium without dizziness. Probably, these figures would

be increased considerably if many middle-aged people did not

consider a slight lessening of hearing a manifestation of

physiological aging.

In patients with the initial forms of neurinomas

otologists do not make the diagnosis of neurinoma for a long time,

connecting the hearing difficulty with other diseases. This is

the explanation for why patients in the favorable phase of the

disease do not go to a neurosurgeon for operation.

In the description of the classic symptoms of VIII nerve

tumors both in textbooks of neurology and in the classic works

a sum of symptoms and signs is given which are shown only in

the far advanced stages of tumor development. Total removal

of the tumor in this period is more difficult. After the operation,

as a rule, the facial nerve is affected on the side of the tumor,

and sometimes also other the cranial nerves. Not uncommonly,

conduction symptoms are demonstrated in connection with the

development of secondary vascular disturbances in the area of

the pons and medulla.

It is always difficult to determine the duration of the disease

in patients with auditory nerve neurinomas. Cases have been

described where the patients have lived to advanced old age, and

at autopsy a neurinoma of the auditory nerve has been found as a

chance finding. The duration of the disease is sometimes equal

to many years.

The disease most frequently begins with local symptoms --

with a very slow reduction in hearing in one ear and not uncommonly

ringing in it. Less often, the disease begins with dizziness or a

loss of equilibrium without dizziness. Sometimes, a loss of

hearing or deafness is found by the patients by chance. Rarely,

a local pain behind the ear with radiation to the occiput or to the

orbit on the side on which the tumor is located precedes the

ringing in the ear or the reduction of hearing. In women, not

uncommonly the disturbance in hearing is found during pregnancy.

In connection with a slow and gradual reduction of hearing and

good compensation of the auditory function by the healthy ear,

as well as the frequent absence of ringing in the ears, the patients
not uncommonly
do not notice the slowly developing deafness.

In the early stage of the disease, when the size of the tumor

reaches 2-3 centimeters in diameter, an investigation of the

recruitment phenomenon (Fowler, M. Dix, Hallopike and Hood

and others) is of great importance for the purpose of

differentiating between involvement of the VIII nerve in the
cochlea or in the nerve root.

It has been determined that in case of cochlear involvement
the hearing disorder decreases from the auditory threshold level
with the increase in the intensity of the stimulus until a level is
attained at which the sound is heard equally well by both ears
(positive "recruitment phenomenon"). In cases of nerve root
involvement, the patient will hear the sound worse on the
affected side with any increase in the intensity of the sound in
the healthy and affected ears (negative "recruitment phenomenon").
In addition to varying degrees of loss of hearing in the early stage
of the disease, a loss of vestibular function of varying degrees may also
be noted. Nystagmus may be absent, and when it is found it is
directed toward the healthy side. On the affected side a reduction
in the corneal reflex and of sensitivity in the nose may be noted
early. Elliot explains this by involvement of the motor portion
of the reflex arc in the facial nerve and not as an obligatory
involvement of the sensory portion of the V nerve. An almost
constant and early symptom is a loss of taste in the anterior
two-thirds of the tongue in connection with the involvement of the
intermediate nerve in the   internal auditory canal in the

process.

During the early period of the disease slight disturbances in equilibrium may be observed as a manifestation of vestibular insufficiency rather than as the result of an effect on the cerebellum, because in this stage the neurinomas are still too small to affect it (Elliot).

A normal composition of the spinal fluid or an increased protein content of varying degrees may be found.

According to the data of the X-ray department of the Institute of Neurosurgery (Professor M. B. Kopylov), in VIII nerve neurinomas there is a relative parallelism between the otoneurological semiotics and the X-ray data found. In approximately 60 percent the presence of the cardinal roentgenological sign of destruction of the internal auditory canal is combined with deafness; in approximately seven percent there is destruction of the internal auditory canal in the presence of hearing, which may be considered an "early" X-ray diagnosis; in 10 percent, the destruction of the internal auditory canal was not found, but in part of the cases there was an osteoporosis or a thinning out of the apex of the pyramid.

Apart from craniography, pneumoencephalography without the removal of spinal fluid and vertebral angiography

are of great importance in establishing the diagnosis of an VIII nerve tumor.

In 1959, a monograph was published by B. Liliequist concerning the encephalographic diagnosis of tumors of the lateral pontine cistern by means of the intraspinal injection of a small quantity of air. By special placement of the patient during roentgenography by this method it is possible to obtain a well outlined representation of the VIII nerve tumor, whether large or very small. This method makes it possible to diagnose the VIII nerve tumor in the very beginning stages of development, at a time when it has not reached the size of a cherry. This is well shown on the films presented (Fig. 3).

While the encephalographic examination permits us to diagnose the shape, size and location of the tumor nodule of small dimensions early, in the case of tumors in far advanced stages of development, which by their mass fill out the entire lateral cistern, the surgeon needs to have additional investigations of the blood supply of the tumor nodule, which is attained by vertebral angiography (Fig. 4).

The material of case histories and the study of brain preparations of patients who died from VIII nerve neurinomas
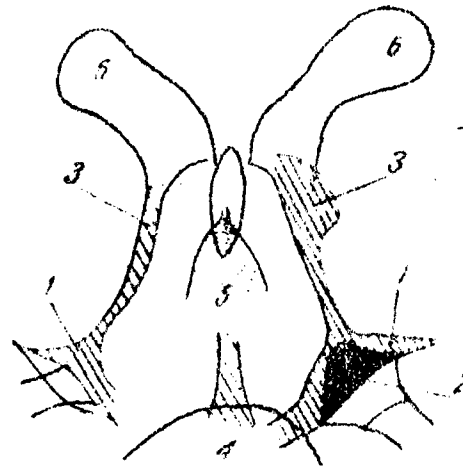
Fig. 3. Pneumoencephalogram after Liliequist

1--lateral pontine cistern; 2--VIII nerve tumor; 3--lateral alae of cisterna ambiens; 4--cisterna magna; 5--fourth ventricle; 6--lateral ventricles.

who had previously undergone operations by the enucleation method according to Cushing, both in the Institute of Neurosurgery and the Academy of Medical Sciences USSR and in other institutions, show that enucleation has a number of negative aspects, which consist of the following: 1) No matter how carefully it is performed half of the tumor tissue almost always remains unremoved; in the best case one-third of it is left; 2) radical enucleation leads to the development of a number of very severe complications; 3) enucleation with a spatula   readily leads to a rupture of the tumor capsule.

In the tremendous majority of observations of operations for the VIII nerve neurinomas the capsule of the tumor nodule has been found to be very fragile and friable; it is almost impossible to grasp it with any instrument. This fact also does not permit the surgeon to hold the capsule of the tumor nodule securely in the process of scraping out the neurinoma mass. It is permissible to scrape out tumor masses from under the capsule only in the event the section of tumor being scraped out by the spatula can be brought out of the depth of the wound and the capsule covering it can be seen by the surgeon, so as to

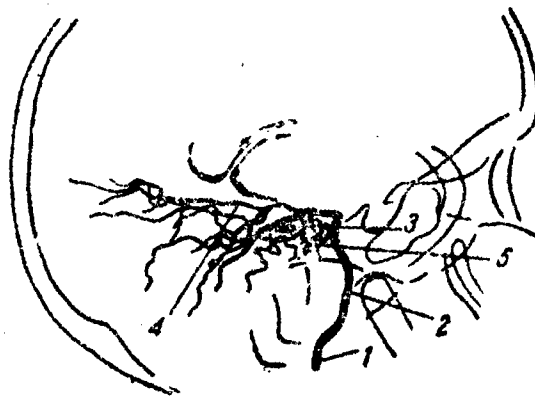control the possibility of perforation.

Fig. 4. Vertebral Angiography. The shadow of a large tumor of the lateral pontine cistern is seen, the anterior portions of which tumor extend into the middle fossa. The superior cerebellar artery is displaced sharply upward in an arc.

1--vertebral artery; 2--basilar artery; 3--superior cerebellar artery; 4--posterior cerebral artery; 5--vascular network of tumor.

From these brief comments it becomes clear how responsible and difficult the removal of tumor masses is in depth, and particularly where the tumor is intimately adherent to the medulla, pons or to the system of basilar arteries.

We have already noted that after enucleation of the tumor frequently recourse has to be had to repeat operations in connection with the continuing growth of the neurinoma. The repeat operations are difficult to perform because of the

abundance of scar tissue which is present even around the

tumor nodule. It is always necessary to take into consideration

the possibility of the presence of latent bacterial forms in the

scars after the first operation, the route of which always passes

into the area where the lymph nodes are located in the posterior

cervical area.

We are presenting the far from complete list of facts

indicating the possibility or even the necessity of revision of our

attitudes in the method of surgical treatment of neurinomas of

the VIII nerve.

The difficulties and dangers which occur in the method of

total removal of VIII nerve neurinomas, which in a large percentage

of cases lead to complete recovery without the threat of

continuation of growth of the tumor nodule, permit us to

consider that total removal should and can be used but only

under conditions of carefully worked out indications. In the

far advanced stages of the disease careful consideration should

be given to the difficulties which may be encountered in this case.

In the early stages, total removal of the tumor should be

considered the operation of choice.

The method of total removal of VIII nerve neurinomas has

been presented well in numerous works (W. Dandy, G. Olivecrona, B. G. Yegorov and others). Our small experience in total removal of neurinomas at the Institute of Neurosurgery of the Academy of Medical Sciences USSR permits us to shade in certain aspects of the details which, in our opinion, can bring benefit in performing this very difficult operation.

It bears repetition that in certain details of the method we are not claiming any particular originality in the description of the method. Either of two positions of the patients on the operating table may be used during the operation -- on the abdomen with the face down or on the side; this depends on the opinion to which the neurosurgeon adheres and on which position is more convenient for the patient.

General anesthesia is to be preferred. The use of endotracheal anesthesia in combination with hypothermia, which makes it possible to carry out the operations in the patients successfully with far advanced tumors, should be considered best. Thus in patient F. the anterior pole of the tumor had reached the trigeminal nerve root, and the posterior portions of it were located over the foramen lacerum posterius, covering the roots of the vagus nerve. A considerable portion

of the tumor was located under the brain stem, markedly

deforming it. Nevertheless, the operation itself and the

postoperative period proceeded favorably; the patient was

discharged home in satisfactory condition.

In patients in the late stage of the disease the use of

endotracheal inhalation anesthesia and hypothermia is

preferable to local anesthesia and intravenous barbiturate

anesthesia given during the phase where pain occurs. Even

during very traumatic operations during the removal of tumors

of large size we have not observed any disorders of respiration

and no kind of overt disorders of cardiovascular activity.

Frequently, the marked variations in blood pressure observed

during the removal of part of the tumor adjacent to the brain

stem   were reduced considerably or were altogether

absent with the use of hypothermia and inhalation anesthesia. At

the same time, the intubation catheter introduced into the trachea

provided for the most efficient method of artificial respiration

in case of need.

In patients operated with the use of endotracheal anesthesia

and hypothermia the postoperative period also proceeded much more

favorably. As a rule, the bulbar disorders (of swallowing and speech)

were less pronounced. No considerable respiratory disorders

were observed. The fact that none of the patients of this group had to have a tracheotomy, which, as is well known, is performed in connection with gross bulbar disorders of swallowing and developing disturbances in respiration, can serve as an indication of this, to some degree.

We did not observe any complications associated with the use of endotracheal anesthesia and hypothermia.

The better course of the operation and of the postoperative period with the use of endotracheal anesthesia and hypothermia is apparently explained by the fact that deep anesthesia and the reduced body temperature markedly reduce the reactivity of the body by blocking the hypophyseal-adrenal system, as a result of which both the operative trauma itself and (which, in all probability, is more important) the hemodynamic changes in the brain stem which occur after removal of the tumor are tolerated much more easily.

The hypothermia and deep anesthesia prevent the development of decompensation of the function of the brain stem, and in the case it does occur they create more favorable conditions for the development of compensatory processes.

During recent years, at the Institute of Neurosurgery a

method has been developed for using ganglion-blocking

preparations in neurosurgical operations and during the

postoperative period. For the five years which have passed since

the first operation with the use of this method the Institute has

accumulated considerable experience, more than 1400 major

operations with the application of ganglion-blocking agents.

This experience makes it possible to draw a conclusion concerning

the value and effectiveness of this method in neurosurgery,

particularly during the removal of brain tumors of localizations

which are most difficult with respect to removal (B. G.

Yegorov and E. I. Kandel', 1956, 1958; E. I. Kandel', 1957).

In 1959, the results were presented of the application of

ganglion-blocking agents in surgery of VIII nerve neurinomas.

The data obtained permitted us to draw a conclusion as to

the expediency of using ganglion-blocking agents and the value of

using this method in surgery of VIII nerve neurinomas. The

ganglion-blocking agents notably reduce the frequency of

complications (bleeding, shock, acute cerebral edema, et cetera)

both on the operating table and in the postoperative period; the

possibilities for a radical removal of the tumor are improved,

and the course of the postoperative period is improved; the

postoperative mortality rate is reduced. At the same time, a series of data has been obtained which make the method of using ganglion-blocking agents more precise and also concerning details of their effect on the blood pressure and respiration under conditions where the brain stem is affected.

The total removal of VIII nerve neurinomas does not require a tremendous trephine opening in the Cushing or Dandy method; a unilateral trepanation of the squama occipitalis from a linear paramedian incision can be completely adequate. The trephine opening usually has an irregular shape. The margin of the resection of the squama occipitalis reaches the linea nuchae superior above, and in the midline, the crista occipitalis externa; below, the margin of the foramen magnum; and externally, the occipitomastoid suture. In those cases where the surgeon has to extend the limits of the trephine opening mentioned above, this may be achieved by means of resection of the margin of the foramen magnum and expansion of the trephine opening beyond the midline by means of cutting off a piece of the crista occipitalis externa and resection of the occipital and nuchal planes of the opposite side (Fig. 5).
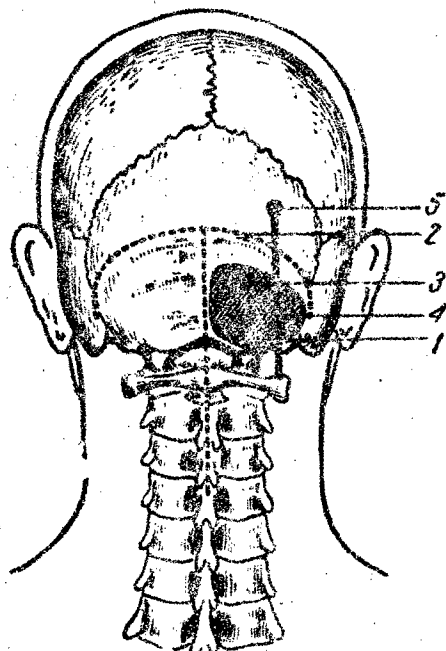
Fig. 5. Paramedian Approach to the Tumor.

1--line of paramedian incision; 2--line of Cushing incision (broken line);
3--the site and shape of resection of the squama occipitalis is hatched in;
4--margin of trephine opening--the occipitomastoid suture; 5--site for
puncturing posterior cornu of right lateral ventricle.

After the resection of the squama the dura mater is

incised by a radial incision, whereby flaps of the dura mater

are traversed with sutures and attached to the towel covering

the brain. Then, a puncture is made into the posterior horn

of the lateral ventricle on the same side. The puncture is

made only with a dull cannula, not with a needle. The quantity

of spinal fluid released   varies; it should be released

in small portions, until the outflow of a stream stops, and a pulsating drop of the spinal fluid remains at the end of the cannula. An important factor is the evacuation of the basal cisterns of the spinal fluid.

This is accomplished by means of raising the lower pole of the cerebellar hemisphere with a spatula until the surgeon can see well the arachnoid septa in the area of the foramen lacerum posterius. The readily seen arachnoidal structures are readily torn off with a forceps, after which spinal fluid begins to flow copiously from the basal cisterns and particularly from the cisterna magna. The spinal fluid excreted is absorbed by a pump; after this, the tension of the cerebral hemispheres decreases markedly, and the lateral pontine cistern can be brought readily to the midline and examined.

In the presence of a tumor nodule and when the decision has been made to remove it totally it is necessary to perform a resection of a little more than the outer third of the cerebellar hemisphere. The resection should be accomplished in a technically correct manner; then, it makes it possible to see the operative field readily. The outer third of the cerebellar hemisphere should be cut off strictly in the sagittal

plane; no deviation of the incision to the outside or inside should be permitted (Fig. 6).
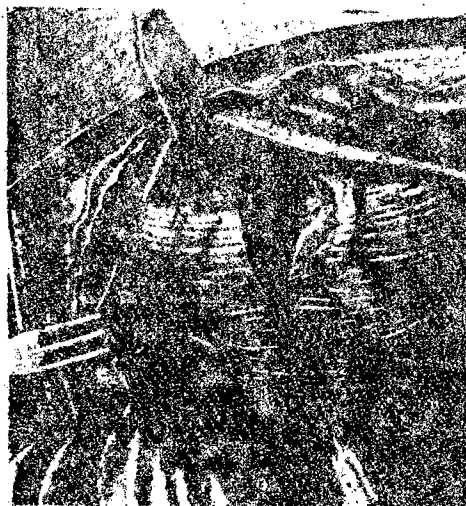

Fig. 6. Sagittal Excisions of Outer Third of Cerebellar Hemisphere with Electric Cautery

We consider it necessary to emphasize the fact that during the operation all the details of the interrelationship of the blood vessels and nerves involved in the total removal of the neurinoma should be seen by the surgeon down to the finest detail, and for this reason the importance of good illumination of the operative field and a good and rapidly working pump are extremely great.

The operation should be begun with the separation of the

lower pole of the tumor from the roots of the IX, X and XI

nerves and the branches of the vertebral artery lying with

them (Fig. 7). After separating the roots by blunt dissection and

very delicately they should be covered with flat wet cotton and

the arterial branch should be clipped. The next phase of the

operation is the freeing of the tumor from the arachnoid

adhesions to the posterior-superior surface of the nodule and

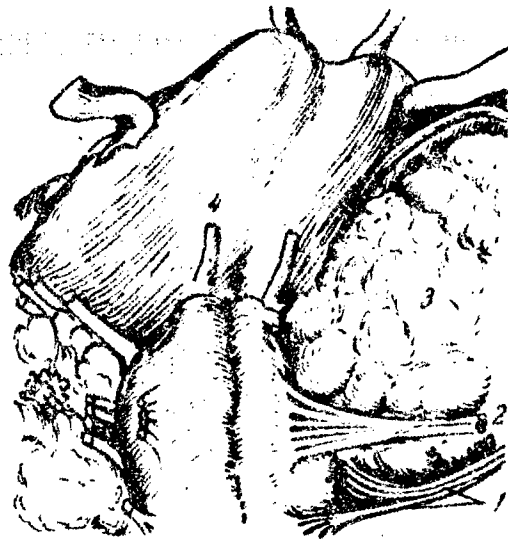the cutting or coagulation of blood vessels located on it.

Fig. 7. Roots of the IX, X, XI Nerves at the Lower Pole of a Tumor
Nodule. These should be separated from the tumor first.

1--roots of the IX, X, XI nerves; 2--XII nerve; 3--neurinoma of the
VIII nerve; 4--pons.

Then, a longitudinal incision is made through the tumor

capsule, and an enucleation is performed of the tumor tissue in

small portions. Not uncommonly, quite considerable bleeding

occurs here, particularly from the cavernous areas of the tumor

tissue. Both the blood vessels within the tumor and the blood

vessels which constitute the cavernous areas possess certain

characteristics in their structure: they practically do not have

a tunica muscularis, and for that reason they do not collapse and

they bleed stubbornly. Usually, this bleeding from tumor tissue

is stopped only when these portions have been removed. The

enucleation is usually finished after the volume of the tumor

nodule becomes less and the margins of the tumor capsule^{are} free

enough so that they may be grasped with some very soft clamp.

By pulling on the margins of the capsule the tumor nodule should

be very cautiously and slowly drawn backward, taking it away

from its contact with the medulla and pons. The tumor should

be separated only with moist cotton sponge with very delicate gentle

movements, clamping every blood vessel encountered. This first act

of removing the nodules from the brain elements is a very important

one, and it should be performed only under conditions where there

is good illumination of the operative field. Here, the surgeon is

often met with a special form of connection of blood vessels from the main basilar artery system to the tumor nodule.

According to the observations of A. S. Arutyunova (Institute of Neurosurgery of the Academy of Medical Sciences USSR), the main source of blood supply of tumors of the auditory nerve is the anterior-inferior cerebellar artery (the usual diameter of it is two millimeters), which comes off the lower third of the lateral surface of the basilar artery and which approaches the tumor nodule from its ~~internal~~ medial side. Either the main branch of the anterior-inferior cerebellar artery approaches the tumor nodule or a branch which comes off it   near the ~~base~~ basilar artery. On the anterior surface of the tumor nodule (hidden from the operating surgeon) this artery divides into a number of branches which are smaller and penetrate into the depth of the tumor. In some cases, aside from the anterior-inferior cerebellar artery, some pontine arteries (Fig. 8) approach the tumor. Branches of the superior cerebellar artery as well as of the posterior-inferior cerebellar artery, after curving out from the IX and X pairs of cranial nerves, also approach the tumor.

The anterior-inferior cerebellar artery, as a rule, is the main source of blood supply of auditory nerve neurinomas; this is obviously associated with the fact that the internal auditory
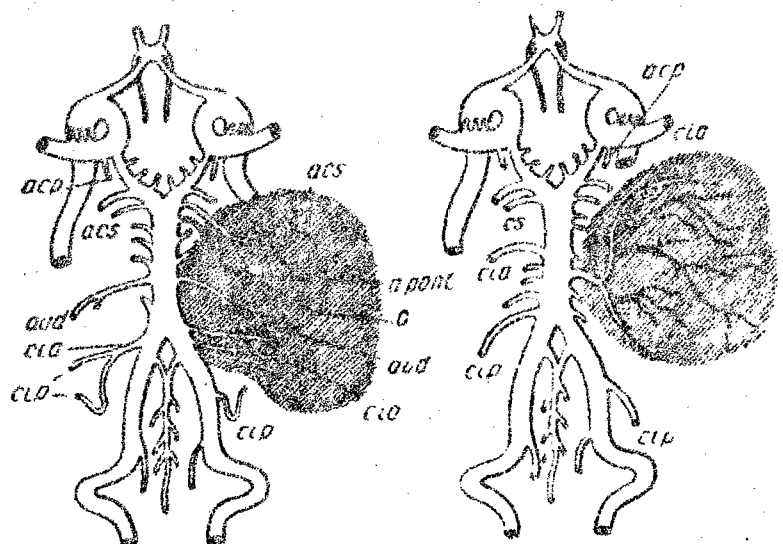
artery most often comes off this artery.

Fig. 8. Diagrams of Blood Supply of Tumor Nodules.

acp--posterior cerebral artery; acs--superior cerebellar artery;
aud--auditory artery; cia--inferior anterior cerebellar artery; cip--
posterior inferior cerebellar artery; a. pont.--pontine artery; c--tumor.

In the process of separating the neurinoma tumor nodule

the surgeon faces the posterior surface of the tumor nodule, and

the blood vessels which have been described above are located on

the anterior surface and encircle the anterior surface of the tumor

like a hoop. These interrelationships determine the actions of the

surgeons. By separating the tumor nodule from the medulla by

means of drawing it backward and laterally toward the petrous pyramid

of the temporal bone, as though rolling it over, we achieve good

visibility of all the blood vessels coming up to it and thereby

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prevent rupture of them, which would be inevitable if the tumor

nodule were separated from the pyramids in a direction toward the

midline.

All the blood vessels encountered here should be

clipped and cut between the clips. In addition, not uncommonly

the central end of the VIII nerve is well separated in the glial

section, where it is never found to be involved by neurinoma.

This part of the nerve should be cut.

When the process of removing the tumor from the brain

stem and pons has been completed, we proceed with exteriorizing

the anterior pole of the tumor. This manipulation also requires

considerable caution and delicacy. The vena petrosa seu

floccularis, which not uncommonly is encountered with several

trunks, should be removed gradually from the surface of the

tumor capsule with a wet cotton sponge. These veins should be

clamped well and moved off the surface of the tumor capsule with

cotton sponges. The V nerve root, which usually is stretched,

is located more anterior and superior to the tumor pole. It should

also be separated off without injuring its integrity. Separation of

the superior-anterior pole of the tumor should be

accomplished with particular delicacy, without injuring the brain

elements. Of the complications observed after total removal
of the tumor during this act of the operation mention should be
made of hemorrhagic softenings of the pons and in the cerebral
peduncles.

When three sides of the tumor nodule have been
exteriorized, it should be separated along the posterior surface
of the temporal pyramid, coagulating the tumor pedicle, which
goes into the internal auditory meatus; the part of the tumor nodule
which lies in this canal should be destroyed by scraping it out or
by electrocoagulation.

As is seen from what has been presented, we have not
anywhere discussed and have not suggested any methods for
preserving the facial nerve, because a radical total removal of
the tumor nodule is always   associated with cutting of
the facial nerve with a subsequent plastic restoration of it (see
V. S. Alekseyeva's work in this issue).

If the act of separating the tumor nodule is performed
methodically, without haste, with consistent clipping of all the
blood vessels encountered, the tumor bed is always deep and
bleeds very moderately. This bleeding is usually stopped well
with warm physiological solution or thrombin solution.

We consider it fitting to say several words about some of

the venous drains of the tumor nodule, which are usually located on the posterior-superior surface and are connected with the superior petrosal sinus. Not uncommonly, the chorioid plexus, coming out of the foramen of Luschka, also communicates with the vascular system of the tumor nodule.

It was not our problem to speak about the complications which are encountered during the total removal of the tumor nodule. However, we consider that it is necessary to mention them, since some prophylactic measures against the complications can and should be included in the act of the operation itself.

We believe that mention should be made of three dire, acute complications: 1) bleeding -- prophylaxis: knowledge of the surgical anatomy, topography, variants of the location in the presence of the pathological focus and ability to handle the tissues; 2) respiratory disturbance -- prophylaxis: the use of endotracheal anesthesia, hypothermia, and where necessary, prompt tracheotomy and the use of respiratory apparatus; 3) facial nerve paralysis -- an inevitable complication in a radical operation -- which can be corrected successfully by means of subsequent neuroplasty -- an anastomosis with the XI nerve (we prefer using the XI rather than the XII nerve, thus avoiding

atrophy of the tongue).

Conclusions

1. The early diagnosis of VIII nerve neurinomas has been worked out clinically and roentgenologically, and it should be popularized extensively.

2. Operations during the early period of the disease undoubtedly lead to almost 100 percent cure and make it possible to avoid a number of operative complications.

3. Operation in the far advanced stages of the disease may be radical but it must be done with a compulsory consideration of the patient's general condition.

4. The technique of total removal of the neurinoma has been worked out in detail and has been given an anatomical-physiological foundation. It can be recommended for use in the practice of neurosurgery.

5. Radical removal of VIII nerve neurinomas completely eliminates the possibility of continued growth and recurrence of the tumor.

6. The use of ganglion-blocking agents, endotracheal anesthesia and hypothermia during total removal of the VIII nerve neurinoma should be considered indicated.

7. In neurosurgical practice total removal of VIII nerve neurinomas undoubtedly is in the group of the most difficult operations, requiring considerable neurosurgical experience on the part of the operator.

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